# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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## GENERAL PHYSICS.

1265. *Trustworthiness of the Balance over Long Periods of Time.* **G. Dean.** (Chem. Soc. J., Trans. 115. pp. 826–828, July, 1919.)—In comparison with the results obtained by Blount [Abs. 4 (1918)], the author gives the results of a series of experiments carried out with silica flasks, each flask being provided with a similar flask as a counterpoise. The total variation in weight of a flask weighing 40·65 gm., in two years, was found to be +0·000128 gm., made up of +0·000062 gm. in the first ten months, +0·000041 gm. in the succeeding four months, and +0·000020 gm. in the final ten months. The error thus likely to be introduced by the duration of any ordinary experiment is so small as to be practically negligible. The fact that the variation given above was a steady increase favours the view that it is due to a displacement of the knife-edge. T. S. P.

1266. *Elasticity of Ebonite.* **M. Pierucci.** (N. Cimento, 18. pp. 86–89, Aug., 1919.)—Regarding ebonite as an isotropic body, the author determines Young's modulus in the case of a rod 2 mm. in diam. of a specimen of ebonite of density 1·165. The value obtained is 84·8 kg./$\text{mm}^2$ at 15°C. The coefficient of cubic compressibility is 0·0081, and Poisson's ratio 0·385. E. E. F.

1267. *Erosion of Guns.* **M. Okôchi.** (Tokyo Univ. Coll. Engin., J. 9. 7. pp. 239–265, March, 1919.)—In modern guns of large calibre firing heavy projectiles at high muzzle velocities, fine fissures on the surface of the bore at the vicinity of the forcing cone may be observed from the examination of gutta-percha impressions after several rounds are fired. Further firings render these small cracks wider and deeper, extending throughout the length of the bore; finally they enlarge the diameter of the bore, particularly at the beginning of the rifling, so that the centring cone for projectiles approaches nearer and nearer the muzzle of the gun. This increase in diameter of bore, whatever its cause may be, is generally called the erosion of guns. The enlarged bore increases the volume of the powder chamber and results in a fall of muzzle velocity, and irregularity in centring during the travel along the barrel causes gyroscopic motion of projectiles during flight. Thus the reduced muzzle velocity and instability of projectiles during flight put the gun out of service through inaccuracy of fire. The number of rounds which can be fired with sufficient accuracy is called the life of the gun, and depends largely upon calibre and max. pressure at firing.

Many theories have been published concerning gun erosion, but the author is not satisfied with the explanations they offer. The chemical erosion theory is based on the fact that modern smokeless powder, containing a large quantity of nitrogen, produces by combustion nitrogen-monoxide gas which may corrode the bore surface. Hardening and surface carburisation by carbon or some product of incomplete combustion, has been proved by metallographic examination of specimens in which the formation of martensite is generally recognised. As the hardened thin layer of martensite structure formed on the surface of the bore is very brittle, the mechanical action of high-pressure gas or the temperature stress at firing, and also the rubbing of the projectile, will cause numerous fine cracks; this action is considered to be the first step of gun erosion. Erosion caused by pure mechanical action of the gas combined with the heating is variously explained as follows:—(1) The leakage of high-pressure gas carrying unburned particles of the powder charge and particles of the metals detached by friction between the driving band of the projectile and the surface of the bore eats away the material of the gun barrel. (2) The friction between the driving band and surface of the bore itself wears off the material so that the diam. of the bore is enlarged. (3) By the vortex motion of gas streaming at enormous velocity, and charged with unburned powder, the skin of the material is scraped, especially at the front part of the powder chamber where the forcing cone (front cone of the powder chamber) causes acceleration of the gas stream by the reduction of the cross-section of the bore. (4) The temperature of the gas being over 2500°C., the gas stream melts and scratches off a thin layer of metal from the surface of the bore. (5) By the thermal expansion and contraction of the gun barrel due to firing (*i.e.*, the temperature stress) and the stress caused by the gaseous pressure a thin cylindrical layer on the inner surface of the barrel is stretched beyond the elastic limit and fine fissures are produced.

It is evident that the causes of gun erosion have not yet been fully explained, although the temperature of combustion of smokeless powder plays a vital part. No decisive experiment, however, has been conducted to determine the temperature of combustion of explosives or to find out the temperature of gun barrels at the instant of firing, and the former has at present to be calculated on assumptions based on the results of calorimetric measurement. Several means have been applied to overcome the erosion troubles. Lowering the combustion temperature by adding a certain quantity of carbon or graphite to the powder charge seems to be successful; erosion is also diminished by coating after each round with graphite or grease, so as to decrease friction between the surface of bore and the driving band of the projectile. Another means is the improvement of the form of the forcing cone and the driving band of the projectiles so as to prevent the leakage of gas at the beginning of the rifling, where the erosion is most serious. Section II of the present paper deals with the resisting power against gun erosion of various materials. Section III considers friction in the bore. Section IV discusses the fine fissures on the surface of the bore. In section V the thermal phenomena in the bore of guns are described. Whatever the causes of gun erosion, all investigators agree that it can be minimised by reducing the temperature of combustion of the powder charge;

so that these thermal phenomena constitute a very important problem and are treated very fully in the paper. Section VI deals mathematically with thermal stress in the gun wall. In section VII the thermal expansion and transformation of steel is considered. The temperature stress has been found to increase with the thermal expansion coefficient which is generally considered almost constant up to the temperature of transformation of steel, but an abnormal change of dilatation is then observed. The author has conducted experiments with Majima and Sato in connection with the thermal dilatation of several kinds of gun-steel at high temperatures in which the specimen was found to expand up to the transformation point and then suddenly begin to contract until the structure became completely austenic, after which it expanded as the temperature increased. Illustrative curves are given for different steels, with tables of results. It is shown that the coefficient of contraction increases with the carbon content in low- and medium-carbon steels. The coefficients of contraction of molybdenum and tungsten steels are remarkably small compared with those of nickel and nickel-molybdenum steels. Section VIII deals with the causes of crack formation, which latter plays such an important rôle in gun erosion. The cause of their formation is mostly the stress resulting from the transformation of structure of the steel. Further reason has been shown why the higher carbon steel is more erosive than low-carbon steel, and why nickel or nickel-molybdenum steel has less resisting power against gun erosion than ordinary gun-steel. A comparatively longer life of the bronze gun can also be explained by the fact that there is no crack produced by the transformation of material. H. H. Ho.

**1268.** *Properties of Metals.* **F. Haber.** (Preuss. Akad. Wiss. Berlin, Ber. 30. pp. 506–518, 1919.)—Discusses various properties (such as compressibility, sublimation, selective photoelectric effect) of the metals Li, Na, K, Rb, Cs, Cu, Ag, Tl, with special reference to Mie's theory. [See Abs. 942 (1912).] A. W.

**1269.** *The Quantelation of Gyroscopic Motion.* **P. S. Epstein.** (Phys. Zeits. 20. pp. 289–294, July 1, 1919.)—Section 1 of this paper deals with the three different methods for the quantelation of the asymmetrical top. Reference is first made to an exhaustive discussion of this problem by Planck. [Abs. 1862 (1916).] Then follows brief notice of the author's previous work on the quantelation of separable systems, and his error in regarding the problem as inseparable, which latter view was successfully disputed by Reiche and Kolossoff, by means of a point transformation which enabled separation to be made. Still later Planck has arrived at Reiche's results by a modification of his former mode of treatment. The number of different solutions to the top problem now appear to be reduced to two, namely: the Reiche-Planck, and that given by Epstein. The latter now shows, in section 2 of the paper, that his previous solution based upon the inseparable character of the system can be obtained by a method involving separation and using a transformation given by Bruns in 1885. It is also shown that the final Reiche-Planck formula is identical with that given by the author in 1916. Sections 3 and 4 contain supplementary matter in connection with the author's earlier work on the specific heat of hydrogen. Reference is also made to a recent paper by S. Rotszajn, in which Epstein's expression for th. specific heat is obtained from other considerations. H. H. Ho.

**1270.** *Simplified Method for the Equations of Motion of the Top.* **H. Lorenz.** (Phys. Zeits. 20. pp. 294–296, July 1, 1919.)—The great and increasing importance of gyroscopic motion in physics and technology has led to a desire for simplified treatment without, so far as possible, involving the procedure of analytical mechanics. The present paper attains this object by the study of the plane motion of a point whose orbit is expressed by the polar coordinates $r$ and $\psi$. The acceleration components are derived by aid of the vector diagram, following which application is made to a rotating body of given mass, the equations of motion being then deduced. The paper, which is entirely mathematical, should be consulted in its entirety. H. H. Ho.

**1271.** *Some new Porous Walls for Unsymmetrical Filtration.* **L. Benoist.** (Comptes Rendus, 168. pp. 1320–1321, June 30, 1919.)—During the course of researches carried out during the war for the detection of the arrival of asphyxiating gases by means of an automatic apparatus based upon diffusion phenomena and Graham's law (the selective diffusion of gases of different densities through a porous partition), the idea occurred to the author that if a special porosity could be realised where the diameter of the pores should vary progressively from one side of the partition to the author, the passage of a gas or liquid through such a partition, instead of being made with the same velocity in both directions, would be accelerated in the direction of the increasing diameter in analogy with the Venturi-effect (the increase in rate of liquid-flow through conical pipes). Types of porous earthenware plates which could be obtained are described. The rates of flow of the same volume of water under the same initial pressure through such plates in opposite directions were measured, and results in accordance with theory obtained. The author forecasts useful service for these plates in a number of scientific and industrial applications. H. H. Ho.

**1272.** *Validity of Stokes' Law.* **W. Gerlach.** (Phys. Zeits. 20. pp. 298–299, July 1, 1919.)—In this paper it is shown that the experimental determination of the mobility of ultra-microscopic particles leads to results which cannot be explained by the theory of the limiting velocity of fall of small spheres (Stokes-Cunningham law) or by the theory of the Brownian movements. [See Abs. 788 (1910).] A.W.

**1273.** *The Gravitational Field and Curvature.* **F. Jung.** (Phys. Zeits. 20. pp. 274–280, June 15, 1919.)—This paper is entirely mathematical and does not admit of an abstract. Reference is made to an earlier paper on the derivation of the gravitational field equations. [See Abs. 608 (1918).] H. H. Ho.

**1274.** *A New Extension to the Relativity Theory.* **H. Weyl.** (Ann. d. Physik, 59. 2. pp. 101–133, June 20, 1919.)—Chap. I of this paper deals with the geometrical basis of the theory. It is pointed out that in order to characterise the physical state of the world, its place must be defined by coordinates, while certain units of measurement must be established. The first point only, namely, the arbitrary character of the co-ordinate system, has hitherto been dealt with in the Einstein relativity theory, and the present paper now takes up the consideration of the second point—the units of measurement. Chap. II investigates the field laws. Chap. III considers the derivation of a special action-principle, and includes a discussion of the problem of matter and the probable universal law. The paper is mathematical throughout. H. H. Ho.

**1275.** *Successive (Heredity) Mechanical Actions rendered Discontinuous by Propagation; a Dynamical Theory of the Quanta Atom.* **M. Brillouin.** (Comptes Rendus, 168. pp. 1318–1320, June 30, 1919. Rev. Gén. d'El. 6. pp. 107–109, July 26, 1919.)—The author considers the motion of a particle in an elastic medium having a speed much greater than the velocity W of the elastic wave. He assumes that the particle gives rise to waves at each instant which emanate from its instantaneous position as centre, and which arise either from the particle vibrations or as a consequence of the displacement in the medium. If the trajectory be periodic or quasi-periodic and always performed within a sphere whose diameter is much less than the product WT of the period by the velocity, then the particle will be met again at any instant a finite number of times by the waves which have been emitted in the course of its motion. The field thus created has been termed an heredity field, following the nomenclature of Volterra. From this investigation the author formulates a dynamical hypothesis in order to represent the essential characteristics of Bohr's atom, namely : In addition to the velocity of light the universal medium (the ether) possesses a velocity of propagation which is much less [of the order of some tens of kilometres per sec. (?)]. The quanta phenomena appear when the electrons move with a speed greater than this velocity, the length of the quasi-periodic orbit, in such a way that the electron may be at any instant in the field due to a finite number of its antecedent positions. The nature and magnitude of the mechanical discontinuities which accompany a change in the above finite number, depend on the law of emission of the moving electron and on the nature of the propagated wave (with or without rotation). As a particular hypothesis, if the energy of the mobile point in the field of one of its antecedent positions is represented by $\Phi = \mathrm{IB}^2/r_2$, then the equation which determines this position may be written $\Phi\int_{M2}^{M} ds/u = \mathrm{B}^2/\omega$. This first member is an action which plays a part in the motion of the point, and the second equation shows that this action has a constant value.

Erratum. (Comptes Rendus, 169. p. 48, June 30, 1919.) H. H. Ho.

**1276.** *Force-Function in Relativity.* **H. Jeffreys.** (Phil. Mag. 35. pp. 113–115, July, 1919.)—W. Wilson has shown [Abs. 379 (1919)] that in the ordinary theory of relativity the equations of motion of an isolated particle can be reduced to Hamilton's canonical form, and also on Einstein's 1915 theory for a particle in a gravitational field. It is here proved that the same holds for Silberstein's form [Abs. 910 (1918)] of general relativity, and, further, that this canonical form implies the existence of a force-function.

G. W. de T.

**1277.** *On the Structure of the Atomic Nucleus and its Tendency to Disintegrate.* **W. Kossel.** (Phys. Zeits. 20. pp. 265–269, June 15, 1919.)—From considerations of the atomic weights and atomic numbers of the elements in the periodic table, the author draws the conclusion that the atomic nuclei consist either entirely of an integral number of helium-nuclei, or of a preponderance of such nuclei with additional nucleus-electrons. If $z$ represents the number of nucleus-electrons in an element, it is assumed that $z = \mathrm{A}/2 - \mathrm{N}$, where A is the atomic weight, and N the atomic number of the element. Plotting $z$ as a function of A, it is found that the former increases in a regular manner as the atomic weight increases. A good approximation of the form of this function is given by the empirical relation

$(z-28)^2=0{\cdot}04A^2+784$. (A hyperbola.) For the lighter elements (*e.g.*, C, O, Ne, Mg, Si, S) $z=0$, the atomic number being exactly half the atomic weight, and the nucleus consisting entirely of helium-nuclei (4). For heavier elements the number of nucleus-electrons increases according to the above relation.

Considering the emission of $\alpha$-particles (helium atoms with 2 positive charges) and $\beta$-rays (electrons with one negative charge) from radio-active substances, the author formulates a general law for the rate of disintegration of elements—namely: "The higher the relative electron-content ($z/A$) of the atomic nucleus, the more quickly follows a disintegration in which it is degraded in the periodic table ($\beta$-ray emission) and the more improbable will be a disintegration in which it is raised still higher in the table ($\alpha$-emission)." Examples of this "law" are given in the cases of Th, Ur, Io, and Ra-Th.

A. B. W.

1278. *Triatomic Hydrogen Molecule.* **N. Bohr.** (Nobelinst. Meddel. 5. [Arrhenius Festkrift], No. 28, pp. 1–16, 1919.)—The author shows that on the assumptions of his 1913 paper [Abs. 15 (1914)], a configuration of H nuclei and electrons containing three atoms is to be anticipated, which, although chemically less stable than $H_2$, would possess the possibility of permanent existence if undisturbed by external agencies. The system will consist of three electrons rotating at equal angular intervals in a circular orbit, the three nuclei being placed, respectively, at the centre of the orbit and at two points on its axis equidistant from the centre. Owing to the total energy being less than 3/2 that of $H_2$, it obviously could not be formed from the latter without a supply of external energy. It might, however, well represent the modifications of $H_2$ of which J. J. Thomson obtained evidence in his experiments on positive rays, and which Duane and Wendt [Abs. 1816 (1917)] obtained when $H_2$ was exposed to $\alpha$-rays, and which in several respects showed analogy with the formation of ozone by electric discharges in $O_2$. No stable configuration is possible of three nuclei at rest and separated by a definite distance with two electrons moving in circular orbits. The removal of an electron from a molecule $H_3$ should therefore result in the splitting up of the remainder into a neutral diatomic molecule and a free nucleus. The interpretation of the observation of positive ions of molecular weight 3 by J. J. Thomson in his experiments on positive rays may therefore be sought in considerations similar to those advanced in the author's former paper as regards the observations of positive ions of molecular weight 2 in these experiments. In analogy with the behaviour of a neutral diatomic molecule, the molecule $H_3$ may be expected to possess the power of binding a free electron. And a stable configuration of three nuclei and four electrons may be found, the three nuclei being at equal intervals in a straight line, while the electrons move in two circular orbits of equal radii with this line as axis and placed symmetrically with respect to the central nucleus. In each of these orbits two of the electrons move at opposite points of a diameter, and for the two orbits these diameters are mutually perpendicular. The total energy of such a molecule being greater than that of $H_3$, the latter, like $H_2$, will be capable of binding an electron to form a negatively-charged ion which may exist permanently in the absence of external disturbance.

G. W. de T.

1279. *Observations on the Work of M. Born and A. Landé with respect to the Crystal Lattice and Bohr's Atomic Model.* **L. Vegard.** (Deutsch. Phys. Gesell., Verh. 21. pp. 383–385, June 30, 1919.)—This paper concerns Born and

Landé's recent work [Abs. 527 (1919)] on the respective distances apart and the binding forces of the atoms in the cubical crystal lattice, based upon the Rutherford-Bohr atomic model. Vegard claims that Born and Landé have utilised his generalisation of the Bohr atomic model in which it is assumed that the normal atom consists of a polyquantic system, Bohr's hypothesis that $ma_i^2\omega_i = h/2\pi$ being replaced by $ma_i^2\omega_i = n_i h/2\pi$, where $n_i$ is a whole number ([the quanta number of the ring][1]), and $a_i$, $\omega_i$, are respectively the radius and angular velocity of the ring. This generalisation, which has found confirmation through the work of Born and Landé, has been ascribed by them to Sommerfeld. In consequence Vegard feels compelled to assert his claims. References are then given to his introduction of the generalisation and its application to the Röntgen spectra and related behaviour of elements. Later work on the same subject is also quoted. The author complains that Sommerfeld does not refer to his previous statement of the hypothesis of variable quanta-numbers. Recently Landé has also ascribed to Sommerfeld the conception of one elliptic state common to a whole system of electrons, which idea was previously shown by Vegard to be a consequence of his theory of L-radiation. Finally, he refers to a *résumé* of his work published in the *Physikalische Zeitschrift*. With respect to the distribution of the electrons between the different ring systems, Born and Landé have utilised the author's work upon atomic constitution, but make this difference that for the K- and L-rings they assume 2 and 8 atoms while 8 and 7 are the numbers for Röntgen-ray spectra. Vegard opines that insufficient evidence has been submitted for this change, and desires further data to settle the problem as to whether or not the numbers 8 and 7 will afford as good agreement for the theoretical determination of the lattice constants and the compressibility. H. H. Ho.

**1280.** *Increase of Precipitation with Altitude.* **A. J. Henry.** (Monthly Weather Rev. 47. pp. 33–41, Jan., 1919. Paper read before the Assoc. of Am. Geographers, Baltimore, 1918.)—In recent years an organised effort has been made to obtain data on the rainfall at different heights in the mountain regions which cover the western part of the United States. Some of the results obtained are here summarised, together with data from other parts of the earth. The change of rainfall with height is widely different in regions of moist air mostly under cyclonic control and in those of dry air under anticyclonic conditions. Thus in the Khasi Hills of Assam, where the rainfall is very heavy, the annual fall increases at the rate of 100 in. per 1000 ft. of elevation, whereas on the west coast of Africa in 30° S. lat. the rate is barely 2 in. per 1000 ft. A level of max. precipitation is frequently found above which the fall decreases again. Thus in the island of Hawaii this level of max. fall occurs below 3000 ft., but in the neighbouring island of Kauai different conditions appear to hold, and a fall of 518 in. per year is recorded on the summit (5075 ft.). Turning to N. America, a diagram shows profiles of sections through the Cascades and Sierra Nevadas, with the accompanying distribution of rainfall. It is found that the greatest fall is in both cases recorded some 30 miles to windward of the highest ground. The paper contains detail results for many places which do not allow of summarising. J. S. Di.

**1281.** *Influence of Solar Eclipse of June* 8, 1918, *upon Radiation and other Meteorological Elements.* **H. H. Kimball** and **S. P. Fergusson.** (Monthly Weather Rev. 47. pp. 5–16, Jan., 1919.)—The Weather Bureau programme included measurements of both incoming and outgoing heat radiation, observations of shadow bands at stations in or near the path of total solar obscuration, and observations of the usual meteorological elements at about 55 Weather Bureau stations within the zone of 90 % obscuration. The radiation measurements were made at Goldendale, Wash. (1650 ft. above sea-level) with a pyrgeometer of the Ångström type and a pyranometer, the former being employed for outgoing radiation only and the latter for both outgoing and incoming. Unfortunately on the day of the eclipse the sky was much obscured by high cloud, though a break occurred just before the total phase was entered. A diagram shows the variations of total incoming radiation and of diffuse sky radiation alone on the day of the eclipse, with also normal curves under cloudless conditions derived from the adjacent days. The outgoing radiation during totality approximately equalled the normal incoming diffuse radiation from a clear sky. No evidence was found that the exchange of radiation between the instrument and the atmosphere during totality differed to any extent from the exchange which occurs at night under like conditions of temperature, except that it was more than ordinarily steady. The most marked meteorological change during the period of the eclipse was in temperature. At Corona (11,800 ft.) this fell by 5 deg. C. in the interval 28 minutes before to 7 minutes after totality. Thin clouds were present. The passage of a snow squall 85 minutes earlier complicated the temperature changes at this station. The temperature fall at other stations ranged up to 8·9 deg. C. at Salt Lake City, where the sky was almost free from cloud. The most rapid fall of temperature was found during totality, and the most rapid rise about 40 mins. later. Analysis of the pressure changes showed that near the centre line of the eclipse there was a slight increase in pressure 10 or 15 mins. before the first contact, a slight decrease from first contact until 85 mins. before max. obscuration, a more rapid decrease lasting about 20 mins. to a max. depression of 0·008 in., which was maintained from 15 mins. before to 25 mins. after max. obscuration. This was followed by a gradual increase of pressure. Changes of wind which might be ascribed to the eclipse are plotted on a diagram and seem to show a general tendency of the wind to blow towards the shadow from each side, but the pressure conditions at the time were such as to favour small fluctuations of wind, rendering the analysis difficult. It is pointed out that in similar enquiries in the future, all stations should be carefully chosen with regard to site and equipped with autographic instruments. J. S. Di.

1282. *Hypsometric Formula.* **E. Oddone.** (N. Cimento, 18. pp. 78-81, Aug., 1919.)—Derives Laplace's (simplified) formula connecting heights $h$ with barometric readings, $h = 7991 \log_e(\beta_0/\beta)(1 + \alpha t)$, by a new process from the variation in amplitude of an elastic wave propagated through the atmosphere. E. E. F.

1283. *The Cold Winter of* 1917-1918. **P. C. Day.** (Monthly Weather Rev. 47. pp. 570-580, Jan., 1919.)—Over all the interior and south-eastern districts of the United States east of the Great Plains, the two months Dec. and Jan. of the winter 1917-1918, taken together, were the coldest experienced over a very long period. The pressure conditions and air movements associated with this cold weather are here discussed. The cause of the intense cold appears to have been different in the two months. In December extremely low temperatures prevailed in Alaska; at Eagle mean temperature for the month was 34 deg. F. below normal. Winds from a northerly point carried this low temperature down to the central and eastern States, which also became extensively covered with snow. In January, temperature in the far north was not unusually low, but owing to the extensive snow and ice which covered the intermediate country, the air in its passage southward was warmed much less than normal, and therefore reached the eastern States with an unusually low temperature. An outstanding feature of Jan. was the occurrence of a severe blizzard on the 11th and 12th over a large area between the Great Plains and the Appalachian Mountains. In striking contrast to the eastern districts, the region west of the Rockies experienced abnormal warmth all through Dec. The first severe cold in the northwestern States was not felt till the end of January. J. S. Di.

**1284.** *Deviations of Sun's General Magnetic Field from that of a Uniformly Magnetised Sphere.* **F. H. Seares, A. van Maanen,** and **F. Ellerman.** (Nat. Acad. Sci., Proc. 5. pp. 242–246, July, 1919.)—The data employed in a previous paper [see Abs. 472 (1918)] from 68 days between June 8 and Sept. 25, 1914, are now increased by spectrograms from 11 more days in the same period; but the modifications of the elements obtained for the position and revolution of the sun's magnetic axis are quite small, and are accepted as final for that period. The period is too short to give an accurate rotation value, and steps have been taken to remedy this by means of some observations in Sept. 1916 which will enable the period to be carried on till the next sun-spot minimum, but all the work hitherto has been on the assumption that the sun behaves as a uniformly magnetised sphere, and it now appears that this is not justified. Treating separate zones as uniformly magnetised in themselves but not necessarily uniformly with each other the values derived seem to show that the zones within ten degrees of the sun's equator give rise to different elements from those in greater N. or S. latitude up to 45°. The separate differences for period, epoch, and inclination are discussed and compared with the mean values derived from the "uniform-field" solution. W. W. B.

**1285.** *New Comet.* (Nature, 103. p. 514, Aug. 28, 1919.)—A Harvard telegram forwarded through Paris announces the discovery of an 8th magnitude comet by Metcalf on Aug. 20. Further observation by Giacobini at Nice on Aug. 22 gives approximate R.A. 22h. 47m., Decl. 28° 28′ N. R.A. decreasing 39s. per day and N. Decl. increasing 110′ per day. W. W. B.

**1286.** *Planet beyond Neptune.* **W. H. Pickering.** (Harvard Circ. No. 215. Nature, 103. p. 514, Aug. 28, 1919. Abstract.)—In Harvard Annals, 1909, the author suggested an unknown outer body which would perturb Neptune by 1924, and now Russell's measures of Harvard plates indicate a deviation of Neptune from its computed position amounting to 2″. The author computes the position of the disturbing body at its next opposition, Dec. 30, 1919, in R.A. 6h. 35m., and Decl. 23° N., and requests systematic observations of Neptune as well as search for the hypothetical planet, which will be difficult, as the region is in the Milky Way. W. W. B.

**1287.** *Relation of Colour to Intrinsic Luminosity in Stars of the same Spectral Type.* **F. H. Seares.** (Nat. Acad. Sci., Proc. 5. pp. 232–238, July, 1919.)—[See Abs. 906 (1917).] Stars with similar spectra are assumed approximately equal in surface brightness, so that the brighter star is simply the larger. But the difference of size probably involves difference of atmospheric constitution, *i.e.*, difference of absorption and therefore of colour index. The present paper deals with exposure-ratio instead of colour index, and for preference the logarithm of the ratio of the exposure times that will yield blue and yellow images of equal intensity. For simplicity a constant size of image is used, this being attained by varying the aperture. A table of results for 61 Cygni during a period of two years indicates the consistency of the method. Results for 150 stars are discussed, including lists by Adams and Joy, types F, G, K, and M, the A stars of the Taurus stream, and Kapteyn's B-stars. These are plotted in classes according to absolute magnitude.

The giant G and K stars are redder than the corresponding dwarfs, but at F5 and again at M there is no difference. Provisional results for the B-stars suggest that the fainter stars are bluer. Similarly, the A stars show redness increasing with luminosity. Some relations are indicated between neighbouring classes. The method appears to afford a check on determinations of parallax by other methods, and when these fail there is a theoretical possibility of extending the colour method to even fainter stars; but practically the author is not sanguine of success in this direction. W. W. B.

1288. *Spectroscopic Method for Parallaxes of Brighter Stars.* **W. S. Adams and G. Strömberg.** (Nat. Acad. Sci., Proc. 5, pp. 228–232, July, 1919.)—The original attempts to determine the parallax of very bright stars with hardly any parallax were limited by the paucity and inaccuracy of the data, but of late years photographic parallaxes of high accuracy have been obtained in increasing numbers, and also spectroscopic material has been accumulated. For stars of very small parallax, the trigonometrical method, having probable errors nearly independent of the parallax and consequently liable to be larger than the parallax, is unsuitable. The spectroscopic method thus offers a great advantage, and it is shown in the present paper that its results are much more satisfactory for the distant stars, while the measured parallaxes are better for the near stars. Tables are given showing the comparative agreement between the methods, and diagrams illustrating the probable accuracy of the spectroscopic determinations of absolute magnitude. Of the 1500 odd stars now investigated at Mt. Wilson hardly a single serious contradiction has been found between the spectroscopic and trigonometrical results. W. W. B.

1289. *Stream Motion Evidence from Faint Stars near Orion Nebula.* **A. van Maanen.** (Nat. Acad. Sci., Proc. 5. pp. 225–228, July, 1919.)—The intention of the investigation is to take account of the second-order terms in the equations from which proper motions have been derived, since the long-focus instruments now in use have so increased the accuracy attainable that small systematic errors can no longer be safely neglected.

Treating separately 18 stars apparently enveloped in nebulosity, 32 near the trapezium which probably share a systematic motion, and 21 variable stars in the region of the nebula, fairly accordant results are obtained. Then, excluding stars with large proper motion, the number of stars and total motion in 15° sectors are plotted on a diagram which shows that most of the stars employed as background are independent of the nebula. The adopted apices for Stream I and Stream II are distinctly indicated, but the evidence of stream motion in stars of 14th and 15th magnitude is not yet regarded as established, until more evidence is collected from other regions of the sky. W. W. B.

## LIGHT.

1290. *Babinet-Soleil Compensator.* **G. Szivessy.** (Deutsch. Phys. Gesell., Verh. 21. pp. 271–283, June 30, 1919.)—Describes an arrangement of a Babinet-Soleil compensator in conjunction with a half-shadow crystal plate, which results in a considerable gain in sensitiveness. The compensator is arranged between crossed nicols, and the half-shadow plate (a thin plate of a double-refracting crystal) is introduced between the analysing nicol and the compensator. A considerable simplification of the theory results if the half-shadow plate is oriented so that its principal oscillation direction coincides with the direction of the optic axis of the compensator. A numerical example is given illustrating the sensitiveness of the method. A. W.

1291. *Electric Double-Refraction.* **F. Himstedt.** (Ann. d. Physik, 59. 4. pp. 332–342, July 25, 1919.)—Describes an experimental investigation of the absolute electro-optic retardation and acceleration associated with the phenomena of electric double-refraction. A. W.

1292. *Curvilinear Ray Refraction.* **W. König.** (Phys. Zeits. 20. pp. 241–245, June 1, 1919.)—Treats a special case of curvilinear refraction suggested by the regions of audibility of firing in the war. The paper is mathematical and obtains data for location of the summit of the path of the rays. E. H. B.

1293. *Optical Properties of Homogeneous and Granular Films of Sodium and Potassium.* **R. W. Wood.** (Phil. Mag. 38. pp. 98–112, July, 1919.)—Calls attention to a number of cases in which colour effects occur, apparently by some mechanism not yet completely understood. The paper is illustrated by diagrams, graphs, and four sets of photographic reproductions. E. H. B.

1294. *Crystallography of Pinaverdol.* **E. T. Wherry** and **E. Q. Adams.** (Washington Acad. Sci., J. 9. pp. 396–405, Aug. 19, 1919.)—This paper gives a detailed description of the crystallography and optical properties of the photographic sensitising dye "pinaverdol," a synthetic dyestuff related to quinoline. Crystals of pinaverdol exhibit a striking and brilliant reflection pleochroism, which phenomenon has hitherto been observed in but few substances. A. W.

1295. *The Dazzle Painting of Ships.* **N. Wilkinson.** (Engineering, 108. pp. 192–195, Aug. 8, 1919. Paper read before the N.E. Coast. Inst. of Engin. and Shipbuilders, July, 1919.)

1296. *The Principles of Camouflage.* **M. Luckiesh.** (Am. Illum. Eng. Soc., Trans. 14. pp. 234–255, July, 1919.)

1297. *Photometric Scale.* **H. E. Ives.** (Frank. Inst., J. 188. pp. 217–235, Aug., 1919.)—Summarises the results obtained in previous work on the various conditions to be fulfilled, and on the values of the constants involved, in accurate photometry of lights of different colours. These are (i) the use of a photometric field of two degrees diameter, a field brightness of 2·5 millilamberts, and a flicker photometer; (ii) the selection of observers by two test colours obtained by means of specified yellow and blue solutions. The group of observers, at least five in number, should obtain an average value of unity for the ratio of the transmissions of these test solutions used with a 4 watt-per-candle carbon lamp; (iii) the luminous efficiency curve of the spectrum is given in three-term form, and the composition of a solution giving a copy of this curve for purposes of physical photometry is described; (iv) the value of the lumen is given as 0·00156 watt of luminous flux; (v) the composition and characteristics are given for yellow and blue solutions intended to reduce colour differences of black-body radiation to equality of hue. J. W. T. W.

1298. *Polarisation Prisms.* **M. Berek.** (Deutsch. Phys. Gesell., Verh. 21. pp. 338–346, June 30, 1919.)—A mathematical paper dealing with the calculation of the polarisation ratios in the field of vision of polarisation prisms. A. W.

1299. *Arc Spectra.* **M. Pierucci.** (N. Cimento, 18. pp. 82–85, Aug., 1919.)—Confirms the conclusions of Lenard, Garbasso, and Puccianti (that the lines of highest excitation are confined to the centre of the arc crater) by a new experiment. A positive carbon is axially perforated to a diameter of 1 or 2 mm. and placed below the negative carbon, both carbons being coaxial. The crater is photographed through the perforation by means of a reflecting prism and lens system, thus eliminating the light of the outer sheaths of the arc. The successive elimination of low-excitation lines as the temperature rises with increasing current is well shown in photographs of calcium and sodium spectra. E. E. F.

1300. *Ritz Formula and the Quantum Theory.* **L. Bloch.** (Comptes Rendus, 168. pp. 1271–1273, June 23, 1919.)—In this paper it is shown that the quantum theory, applied in only a rough manner, leads to spectral formulæ of the Ritz type. Taking the Ritz formula (applicable to hydrogen and helium) to be $\nu = \nu_L - N/\{n + p + \omega(\nu_L - \nu)\}^2$, a first hypothesis consists in interpreting the $p$ and $\omega$ terms by means of the disturbing action exerted on the electron which emits the light by a ring of interior electrons around the nucleus. This leads to the $p$ term of the Ritz formula, the $\omega$ term being zero. The second case considered is where, near the charge $\mu e$, and at a distance from it of $2\epsilon$, there is a second charge $\mu' e$ (positive or negative) fixed with respect to the first. The motion of the electron is supposed to take place in a meridional plane, the two charges being situated in this plane at distances $\pm\epsilon$ from the origin of coordinates. With the distance $\epsilon$ a small fraction of the radius of the atom the quantum theory then leads to a formula which is exactly of the Ritz type. A. W.

1301. *Series Spectra and Bohr's Model Atom.* **F. Tank.** (Ann. d. Physik, 59. 4. pp. 293–331, July 25, 1919.)—Mathematical treatment of Bohr's theory leads to formulæ for the series lines of spectra, which are applied to various series of helium, parhelium, lithium, and sodium. A. W

1302. *Helium Spectrum and the Unit Electrical Charge.* **F. Sanford.** (Astrophys. J. 49. pp. 337–348, June, 1919.)—In a previous paper [Abs. 1250 (1918)] the author has shown how, on the assumption that radiating electrons are revolving in elliptical or circular orbits about a central positive charge, the central positive charge for any wave-length may be calculated in terms of the wave-length and a numerical constant, namely, $Q = 2{\cdot}882 \times 10^{-13}/\sqrt{\lambda}$, where Q is the central charge. It was also shown that the Rydberg constant *N* is the wave-number of an electron revolving about a central positive charge $Q = 2e = 9{\cdot}548 \times 10^{-10}$ e.s. unit. This being the case, it should be possible to calculate the effective central charge corresponding to any line of any series to which the Ritz formula may be applied, in terms of $2e$, by means of an equation of the form $Q = 2e\sqrt{(1/p^2 - 1/q^2)}$. This has previously been done for all the known series of hydrogen. In the present paper it is shown that it may also be done for the six known series in the helium spectrum. Tables are given showing the results of the calculations, the mean values for *e* for the six series being respectively 4·7785, 4·7725, 4·79, 4·775, 4·7725, and 4·775. A. W.

1303. *Duration of Emission of Series Lines.* **F. Reiche.** (Phys. Zeits. 20. pp. 296–298, July 1, 1919.)—Stark has found experimentally [Abs. 780 (1916)] that for the series lines of hydrogen, helium and lithium, the duration of emission increases with increased term number. In the present paper, taking the simplest model for the hydrogen atom (Bohr's theory), and assuming circular electronic orbits, it is shown that for the members of a single series the duration of emission should increase proportionately with the term number. Calculation for the Balmer series gives for the duration of the line $H_\gamma$ the value $9 \times 10^{-9}$ sec. Stark gave an upper limit for this duration of $2 \times 10^{-7}$ sec. It is probable that the formulæ here derived only hold for low values of the term numbers. A. W.

1304. *X-ray Absorption Wave-Lengths of Lead Isotopes.* **W. Duane** and **T. Shimizu.** (Nat. Acad. Sci., Proc. 5. pp. 198–200, June, 1919.)—Careful measurements have been made of the critical X-ray wave-lengths absorbed by ordinary lead (at. wt. 207·20) and by radio-active lead (at. wt. 206·08). The values of these wave-lengths are given in the following table:—

| Absorbing screen. | Atomic weight. | $\lambda \times 10^8$ cm. | $\lambda \times 10^8$ cm. | $\lambda \times 10^8$ cm. |
|---|---|---|---|---|
| Ordinary lead ................ | 207·20 | 0·9485 | 0·8128 | 0·7806 |
| Radio-active lead ......... | 206·08 | 0·9489 | 0·8129 | 0·7810 |

The grazing angles of incidence were measured to within 30″ of arc, so that the wave-lengths are correct within about 0·1 %. It appears, therefore, that the critical absorption wave-lengths of the isotopes of lead are identical within the limits of experimental error. The results indicate also that the relative change of absorption at the three critical wave-lengths is about the same for each isotope of lead. A. B. W.

1305. *Production of X-rays, using very high Voltages.* **F. Dessauer** and **E. Back.** (Deutsch. Phys. Gesell., Verh. 21. pp. 168–200, May 30, 1919.)—For the generation of the very high voltages (up to 310,000 volts) used in these experiments a special type of transformer designed by one of the authors and previously described [Abs. 65B and 898 (1919)] was employed. Using a Seemann spectrograph (*Schneidenkamera*) the limiting minimum wave-length of the continuous X-ray spectrum was measured for different voltages applied to the tube generating the X-rays. It was found that $\lambda_{\text{min.}} = 0{\cdot}075$ Å.U. when $V = 170$ kilovolts. The Planck-Einstein law gives for this voltage $\lambda_{\text{min.}} = 0{\cdot}072$ Å.U. Thus experiment and theory are in good agreement. The shortest wave-length measured in these experiments was $\lambda = 0{\cdot}057$ Å.U.

Using the results of earlier measurements for the absorption constant, the authors have now determined the scattering coefficient of aluminium for the very hard X-rays referred to above. Observations give for a wave-length $\lambda = 0{\cdot}15$ Å.U., $s/\rho = 0{\cdot}046$, in good agreement with the measurements of Ishino, who obtained $s/\rho = 0{\cdot}04$ for hard $\gamma$-rays through aluminium. The wave-lengths of the $K_\alpha$ and $K_\beta$ lines of uranium have been approximately determined. The observed and calculated values are given in the following table:—

| | Observed between | Calculated. | |
|---|---|---|---|
| | | Extrapolated from Pt. | According to the Sommerfeld formula |
| Mean value for $K_{\alpha_1}$ and $K_{\alpha_2}$ | 0·154 Å.U. and | 0·186 Å.U. | 0·146 Å.U. |
| „ „ $K_\beta$ | 0·104 Å.U. | 0·114 Å.U. | 0·131 Å.U. |

A. B. W.

## RADIO-ACTIVITY.

**1306.** *Radio-activity of Rubidium.* **O. Hahn and M. Rothenbach.** (Phys. Zeits. 20. pp. 194–202, May 1, 1919.)—The authors have compared the activities of specimens of rubidium sulphate (1) freshly prepared, (2) 11 years old, and (3) 21 years old. The activities were found to be exactly equal, within the limits of experimental error. The penetrating power of the $\beta$-rays emitted by this element has also been determined by an accurate method. The absorption coefficient in aluminium of the $\beta$-rays from UrX was found to be 468 cm.$^{-1}$, as compared with the value 510 cm.$^{-1}$ found by H. W. Schmidt [Abs. 471 (1909)], and that by Fajans and Göhring, 500 cm.$^{-1}$. The same method, applied in the case of rubidium, gave a value 347 cm.$^{-1}$, and for the soft $\beta$-rays from radium 312 cm.$^{-1}$. The velocity of the $\beta$-rays of rubidium is about 58 to 60% of the velocity of light, in good agreement with the value $1{\cdot}85 \times 10^{10}$ cm. $= 61{\cdot}7$% of the velocity of light, calculated by v. Bergwitz.

A comparison of the total activity of the $\beta$-radiation of equal quantities of rubidium and uranium has also been made, the ratio being 1 : 15, with a 20% accuracy. The ratio Ru/Th, for the $\beta$-radiation, is similarly 1 : 10. The "half-value" period of rubidium is given as $10^{11}$ years. Calculated in the same manner, the period for calcium is 3 to 7 times this number. A. B. W.

## HEAT.

**1307.** *Ratio of Specific Heats for Air from Speed of Sound.* **T. C. Hebb.** (Phys. Rev. 14. pp. 74–84, July, 1919.)—The ratio of the specific heats for air obtained from the author's determination of the speed of sound does not seem to be as high as that obtained by different observers using the Lummer-Pringsheim method. This was thought at first to be due to experimental errors in the determination of the speed of sound. A redetermination gives, however, a value very close to that previously found. The cause of the discrepancy is found to be due to the method of obtaining the speed of sound for dry air at 0° C. from observations made in air containing moisture. The usual transformation omits the term $\surd(\gamma_0/\gamma_m)$, where $\gamma_0$ is for dry air at 0° C. and $\gamma_m$ is for air containing a certain percentage of moisture. The term is small but not negligible; it can be calculated with sufficient accuracy. The corrected values of the speed of sound can then be used to determine $\gamma_0$ for dry air at 0° C. Thus, from the author's 1904 value of the speed of sound, the value of the ratio in question is deduced as 1·4026; and from the 1919 value of the speed, the ratio 1·4031 is deduced. The mean of these values is 1·40285 and is held to be accurate to 2 or 3 in 14,000, the values of the sound speed being accurate to 2 or 3 in 33,000. The theory shows that the ratio of specific heats for a gas consisting of 0·95 % of argon and 99·05 % of oxygen and nitrogen would be 1·4015 as an ideal gas. To this must be added 0·0014 for its deviation from ideal, thus giving 1·4029! E. H. B.

**1308.** *On the Mechanism of Evaporation.* **K. Bennewitz.** (Ann. d. Physik, 59. 3. pp. 193–224, July 4, 1919.)—While the thermodynamic treatment of the evaporation process has recently led to a certain conclusion, the kinetic method has not yet been completely developed. The former is based almost exclusively on the three main thermodynamic laws, while the latter has to depend on a number of more or less established hypotheses. Although thermodynamics leads to correct results yet the kinetic method affords more intimate information with respect to the details of a process, *e.g.*, the theory of specific heat, the Debye $T^3$-law, the definition of the chemical constants, etc. The kinetic derivation of the vapour-pressure formula has been attempted by several investigators including Tetrode, Sackur [Abs. 468 (1918)], Stern [Abs. 1977 (1918)], Planck, etc. All the latter start from the assumption that the number of molecules condensing from a saturated vapour is equal to the number absorbed; *i.e.*, in general no reflection of such molecules takes place. Experimental evidence for this theory, which was first advanced by Boltzmann and Gibbs, has hitherto not been forthcoming. The first part of the present paper deals with this experimental confirmation, while the following part considers the kinetic derivation of the vapour-pressure equation from a new standpoint. Section 1 contains a general theoretical introduction to the experimental determination of emission coefficients. In section 2 the experimental arrangements are described, while section 3 gives a detailed account, with tables of data, of the results obtained. Section 4 discusses an approximate equation at high temperatures as an introduction to the derivation of a vapour-pressure equation from a special standpoint. In section 5 the approximate equation is extended to lower temperatures. Section 6 contains a full discussion of this equation. In section 7 the consequences arising from the definition of the effective surface are considered. Section 8 deals with the emission coefficient, while section 9 is concerned with general deductions. It has been found by means of the method here worked out for the measurement of the absolute evaporation velocity, that the emission coefficient is equal to unity, *i.e.*, that no reflection of molecules takes place at condensation. By means of this result and a definition of the effective surface of a molecule, a vapour-pressure equation has been derived identical with that given by Stern. By more exact consideration of this idea of the effective surface, this equation has been extended so as to hold good for lower temperatures. From the effective surface the layer number and thickness of the condensed surface are derived, and an equation of state is evolved. From the emission coefficient it is seen that the gas pressure may be regarded as the vapour pressure of thin layers. H. H. Ho.

**1309.** *Special Ultra-Red Frequencies of Diatomic Bohr Gas-Molecules, and the Specific Heats at High Temperatures.* **G. Laski.** (Phys. Zeits. 20. pp. 269-274, June 15, 1919.)—The Bohr-Debye hydrogen molecule has hitherto been the only molecular model for which the various phenomena calculated have been found in agreement with experience. Models dealing with other elements have much greater complexity for the quantitative treatment of physical questions. A relatively simple problem, however, is the calculation of special frequencies due to the oscillation of the mass nucleus in the interior of a diatomic molecule, and this offers the possibility of confirmation by experience. These special frequencies occur with those substances exhibiting ultra-red absorption bands which may be identified with the oscillation-numbers of the absorption lines. Similar molecular oscillations can exist, however, when no such absorption lines are present, since the cause of such an oscillation being optically discerned is ascribed to the molecule possessing electrical asymmetry, whereby during the oscillation it may be regarded as a dipole of periodically changing moment. On the basis of the Rutherford-Bohr theory, however, it is possible to calculate the ultra-red frequencies for symmetrical molecules. Comparison of the specific heats calculated by means of these frequencies with experimental values will therefore afford the possibility of testing the validity of the model.

The present paper first applies this test to the known hydrogen molecule, and then extends it to molecules of other diatomic gases such as nitrogen and oxygen. In the case of the nitrogen model the electronic arrangement in the outer ring is discussed, and it is shown that only those molecular models are in agreement with experience whose configuration corresponds to the arrangement of electrons in the nitrogen atom, this fact having first been shown by Bohr, later by Kossel and finally by Vegard from different standpoints. This necessitates the assumption that the inner ring must be made mono-quantic and the outer diquantic in accord with Vegard's result based on the calculation of the Röntgen frequencies for the nitrogen atom. Analogous considerations apply to the oxygen molecule. It is also shown in this paper, without a discussion of the dispersion theory, that the Sommerfeld dispersion formula based upon the molecular models of nitrogen and oxygen leads to a better agreement between the calculated quanta values and the so-called empirical value of the rotation velocity of the electrons than can be attained by means of Sommerfeld's assumption on the constitution of these molecules. Section 1 deals with the specific heats, $C_v$, of gases at high temperatures. In section 2 the special ultra-red frequencies are calculated for symmetrical diatomic molecules. Application is made in section 3 to hydrogen. Section 4 deals with the specific heats and the molecular models of nitrogen and oxygen. In section 5, molecular dimensions and rotation velocities are considered.

As a result it is found that the molecular model for nitrogen consists of 2 positive nuclei of charge $7\epsilon$, at a distance apart of $d = 9{\cdot}1 \times 10^{-9}$ cm. Near to each nucleus lies an inner ring of 2 electrons having a very small radius. The outer ring of 10 electrons is diquantic, and has a radius $a = 8{\cdot}05 \times 10^{-9}$ cm. Its plane divides the molecule into two symmetrical halves. To this molecular model corresponds an atomic model of nitrogen, in which there is an inner mono-quantic ring of 2 electrons about the nucleus and around this a concentric diquantic ring of 5 electrons. The corresponding oxygen molecule has two nuclei of charge $8\epsilon$, two inner rings of two electrons, and an outer diquantic ring of 12 electrons. Analogous to nitrogen the oxygen atom consists of a mono-quantic ring of 2 electrons, and a diquantic ring of 6 electrons. H. H. Ho.

**1310.** *The Measurement of Heat and the Scope of Carnot's Principle.* **A. C. Lunn.** (Phys. Rev. 14. pp. 1–19, July, 1919.)—This paper outlines a symmetric form of exposition of the principles of thermodynamics made possible through recognising on a parity from the outset the two kinds of conservation naturally called after Black and Carnot, each of which is physically valid under proper conditions, and which lead to the energy and entropy scales of measurement of heat; thus exhibiting both of these together with the thermodynamic scale of temperature, as calorimetric concepts. In the two parts of the paper are given respectively an experimental and a deductive treatment.

In part I the experimental meaning of conservation is considered in terms of certain conditions of consistency; first in connection with single-temperature transfers of heat, where those conditions underlie the uniqueness of meaning of an arbitrary scale of heat for various temperatures; second in connection with passages of heat between bodies at different temperatures, which reveal the dual nature of a quantity of heat, here illustrated by some analogies.

In part II are investigated the deductive consequences of Carnot's hypothesis of the universal ratio of efficiency. With only the single-temperature conservation of heat assumed to be known experimentally, (probably the mildest basis on which this principle is intelligible), it is shown that there follows practically the entire theory of reversible thermodynamics, in particular the existence of thermal energy and entropy and the equivalence of thermal energy and work. AUTHOR.

**1311.** *The Joule-Thomson Effect for Air at Moderate Temperatures and Pressures.* **L. G. Hoxton.** (Phys. Rev. 13. pp. 438–479, June, 1919.)—In the experiments as described air was pumped first through a set of tubes designed to remove $CO_2$ and moisture, then through the throttling device or "porous plug" and finally back to the pump. The plug and tubing immediately leading to it were immersed in an oil-bath thermostat. The bath temperatures, for the most part, lay between 0° and 100°C., the mean pressures, from 450 to 640 cm. of mercury, while the pressure-drop varied between 25 and 80 cm. of mercury. The temperature-drop was measured by Pt-resistance thermometers differentially connected. The plug was of the radial flow type originated by Regnault, roughly cylindrical in form, through the walls of which the air flowed towards the axis, escaping finally through one end. The accidental errors were apparently of an order under 1%.

The Joule-Thomson coefficient ($\mu$) was found to have a decreasing linear variation with increasing mean pressures. Its dependence upon both temperature and pressure are embodied in either of two empirical formulæ, namely :—

$$\mu = +0{\cdot}3985 - 0{\cdot}00691p - 0{\cdot}001885t + 0{\cdot}00000184t^2 + 0{\cdot}0000825pt$$

$$\mu = -0{\cdot}2599 + 182{\cdot}0/\tau - 552{\cdot}4\frac{p}{\tau^2},$$

all pressures being measured in metres of mercury, $t$ in degrees C., while $\tau = 273 + t$.

These formulæ are applied to calculate the temperature of the ice-point on the thermodynamic scale, to reduce to the same scale the readings of the constant-pressure air thermometer and to discuss the variations of $c_p$ with pressure. Good agreement with the results of other work is found in the second and third cases, while in the first, the result, in common with that found from other Joule-Thomson data, is higher than the result found from the characteristic gas equations.

The paper includes a brief historical summary of previous experimental work, a discussion of several theoretical points and of sources of error, especially heat leakage. AUTHOR.

1312. *Radiation Constants.* **W. W. Coblentz.** (Am. Inst. Mining Eng., Bull. No. 152. pp. 1288–1884, Aug., 1919.)—A general consideration of the degree of accuracy to which the radiation constants have been determined up to the present time. These are known to an accuracy better than 0·5% and may be taken as $c = 14{,}820$ micron degrees, and $K = 5{\cdot}7 + 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$. J. W. T. W.

1313. *Electric Work during Fluid Emission. An Improved Method for the Liquefaction of Gases.* **W. Meissner.** (Deutsch. Phys. Gesell., Verh. 21. pp. 869–882, June 30, 1919. From the Physikal.-Techn. Reichsanstalt.)—The Joule-Thomson effect is used for the liquefaction of hydrogen and helium, but affords in each case a relatively small yield, since pre-cooling by liquid air reduces the temperature but little below the inversion point of the gas to be liquefied. Another effect recently observed is that the molecular heat of helium, according to Eucken's measurements at constant volume, falls with declining temperature below that for monatomic gases, and, according to Nernst, the fall is greater the denser the gas. A cooling effect can therefore ensue by the expansion of the helium. By emission from a nozzle a much greater percentage of the gas is liquefied than corresponds to the Joule-Thomson effect, due to a partial transformation of the energy of the compressed gas into the kinetic energy of the expanded stream. This kinetic energy, however, is no sooner generated than it is partially transformed by friction into heat, and in consequence cannot wholly assist liquefaction. This dynamical effect may be utilised for cooling purposes if the kinetic energy be otherwise employed, and Rayleigh first suggested its transformation into mechanical work by means of a turbine. This suggestion, while available for large-scale operations, would prove impracticable with the small quantities to be handled in the laboratory liquefaction of hydrogen and helium. The present paper deals with the transformation of this kinetic energy into potential electrical energy, which is then conducted by thin wires away from the liquefaction apparatus. A full description with experimental details is given of a method applicable to non-conducting fluids, comparison being made with the principles involved in Armstrong's steam electrical machine wherein the electrification of the water-drops in the vapour ensues by friction in the nozzle. The paper is illustrated by several diagrams and also contains a mathematical treatment of the subject. H. H. Ho.

**1314.** *On the Modified van der Waals Equation of State for the Quasi-diminution of the Molecules.* **E. A. Holm.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] No. 27, pp. 1–35, 1919.)—The author treats the subject mathematically under five sections, namely: (1) The modification of the van der Waals equation of state for the quasi-diminution of the molecules. (2) The variation of the quantities $a$ and $b$ in the equation of state. (3) The Brinkman and the van Rij proofs of the corrected van der Waals equation of state for the quasi-diminution of the molecules based on Amagat's isotherms for air, oxygen, and hydrogen. (4) A new proof of the problem of Section 3, based on Amagat's oxygen isotherms. (5) Proof of the uncorrected van der Waals equation of state based on Amagat's oxygen isotherms. It has been found that the correction factor of the volume is an infinite series in $b/v$, which Boltzmann and others have only approximated as $1 - b/v + 0{\cdot}375(b/v)^2 - 0{\cdot}0369(b/v)^3$. This mathematically incomplete equation cannot be valid for very small volumes. The limits of application have been studied by Reinganum and v. Smolnchowski. The availability of the modified equation of state has been found to be at 250, 300, 300, and 450 atmos. for 0°, 15·65°, 99·5°, and 199° C. respectively. It is shown that the systematic positive deviation which occurs at high pressures may not be ascribed either to the incomplete character of the equation or to real diminution of molecules by association or to increase of $a$ with decreasing volume, but to the defective character of the coefficients in the correction terms. When these coefficients are diminished, then the systematic deviation is lowered. This result is in agreement with that of Brinkman and van Rij. As a possibility the original equation of state by van der Waals may be valid over a greater range than that corrected for the quasi-diminution of the molecules. For very high pressures up to 3000 atmos. the deviation in the unmodified equation becomes negative at ordinary temperatures and attains very high values; this deviation finds an explanation in the mathematical incompleteness of the equation. In the modified equation this deviation is positive at high pressures, but controlled by the third term in the above modified expression. The author concludes that the coefficients must still be regarded as only partially correct.

H. H. Ho.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1315. *Notes on Electric and Magnetic Field Constants.* **A. Gray.** (Phil. Mag. 38. pp. 201–214, Aug., 1919.)—The paper consists of notes made by the author in connection with the revision of his work on Electric Measurements, and contains some expressions for potentials and forces in terms of Bessel functions, the evaluation of certain elementary Bessel function integrals by means of dynamical considerations, and expression of the Legendrian elliptic integrals in terms of Bessel function integrals. Some of the latter have been evaluated in power series and applied to calculations of mutual- and self-inductance by T. H. Havelock, who published the results in 1908 [*ibid.* vol. 15]. G. W. DE T.

## DISCHARGE AND OSCILLATIONS.

1316. *Surface Brightness of the Positive Crater.* **E. Podszus.** (Deutsch. Phys. Gesell., Verh. 21. pp. 284–293, June 30, 1919.)—In the experiments here described a Kurlbaum-Holborn pyrometer and also a König spectrophotometer were used for the brightness determinations. Carbon electrodes were employed, containing as few impurities as possible. The results obtained with both instruments are concordant, and show a definite dependence of the surface brightness of the positive carbon on the arc conditions. Greater brightness was found with increased current through the arc. Tables of results, showing the arc conditions, are given. A. W.

1317. *Residual Gases and Vapours in Highly exhausted Glass Bulbs.* **J. E. Shrader.** (Phys. Rev. 13. pp. 434–437, June, 1919.)—The investigation of high vacua [Abs. 1023 (1918)] has been extended by making observations on the effect of the sealing off of highly exhausted glass bulbs, and noting the subsequent change in pressure with time over an extended period. On sealing off the bulbs and gauges by melting the glass at a constriction there is a comparatively large evolution of gases and vapours which can be partly removed by pumping during the time of sealing off, but the pressure in the bulbs is always four or five times as large as the pressure before sealing off. AUTHOR.

1318. *Thermionic and Photoelectric Phenomena at the Lowest Attainable Pressure.* **C. F. Hagenow.** (Phys. Rev. 13. pp. 415–433, June, 1919.)—The object of these investigations was fourfold :

1. To study the photoelectric effect of tungsten at the lowest possible pressures, especially after the illuminated plate had been denuded of occluded gases by continued electronic bombardment of such energy as to maintain it at a white-hot temperature.

The pressures attained were as low as $8{\cdot}5 \times 10^{-7}$ mm. of mercury. Upon denuding a tungsten plate of its occluded gases by raising it to a bright yellow heat by electronic bombardment, the photo-current rose to many times the value obtained before such denuding and further heating produced no further change.

2. To find, by direct observation, the short-wave-length limit for tungsten and to observe how this changes, if at all, with the removal of occluded gases.

The upper wave-length limit of tungsten was located in the region between 2100 and 2300 Å. According to Einstein's equation, the corresponding values of the work necessary to free an electron from the metal would then be between 5·7 and 6·3 volts. These are larger than the corresponding values in the case of thermionic emission.

3. To observe, with the aid of the electric vacuum gauge, recently devised by O. E. Buckley, the progress of the clean-up effect, particularly at extremely low pressures.

Under the conditions employed it was not found possible to reduce the pressure by means of the clean-up alone lower than $10^{-5}$ mm., which was not as low as could be attained with the pump itself.

4. To study pressure and other changes accompanying the appearance o the "blue haze."

A gradually increasing potential difference was applied between the tungsten plate and a glowing filament until the blue haze appeared. *No pressure change whatever was observable at the moment of its appearance.* Certain current and voltage discontinuities, which occur under the experimental condition just described, were found to have characteristics similar to those observed by Richardson and Bazzoni in the case of mercury vapour. The clean-up of the blue haze is very rapid and shows a striking increase in its rate of absorption as the pressure approaches the final minimum. This behaviour is in marked contrast to the clean-up with a lighted filament, but without a field, and is quite similar to that observed by Brodetsky and Hodgson in their experiments with a vacuum tube discharge under the condition of abnormal kathode-fall. At the pressures employed in these trials, about 0·01 mm. of mercury, this final pressure remained unchanged in the presence of the field, and did not change further even in those cases in which a trace of the blue glow remained in the tube. AUTHOR.

1319. *Electric Figures.* **K. Przibram.** (Phys. Zeits. 20. pp. 299–303, July 1, 1919.)—The electric figures here dealt with are obtained by applying a high potential difference to two electrodes separated by a photographic plate. One electrode consists of an insulated metal plate on which the photographic plate rests, and the other is of small diameter at the end. Photographs are reproduced showing the different figures obtained with the small electrode positive or negative, the surrounding medium being air, nitrogen, or oxygen at various pressures. The effects obtained can be explained on the ionic theory. A. W.

1320. *Production and Measurement of Short Continuous Electric Waves.* **B. van der Pol, Jr.** (Phil. Mag. 38. pp. 90–97, July, 1919.)—The waves, under 4 m. in length, are produced by means of a three-electrode thermionic tube with suitable circuits (as explained by a diagram). The system presents the following valuable properties :—(1) The constancy of the current amplitude is all that can be desired. (2) The reaction of the resonator on the vibrator can be made negligibly small, while the sensitiveness of the indicating instrument can be varied very simply within wide limits. (3) The continuous vibrations in the oscillator render resonance measurements exceedingly sharp. (4) The wave-length can be easily varied and brought down to a few metres. (5) The wave-length of about 4 m. can be measured to a tenth of a millimetre. E. H. B.

**1321.** *Transmission of Electric Waves round the Earth.* **G. N. Watson.** (Roy. Soc., Proc. 95. pp. 546–568, July 15, 1919.)—In a former paper [Abs. 206 (1919)], the author showed that the observed facts concerning the rate of decay of electric waves transmitted over a large sheet of water were not adequately accounted for by a theory of pure diffraction. He finds, however, that the ionisation theory which results in the upper regions of the atmosphere acting as a reflector of electric waves of great wave-length does adequately account for these facts, so that the results of the paper tend to confirm the existence of the Heaviside layer, as Eccles has called it. The analytical methods are those of the earlier paper, but in order to evade the grave analytical difficulties which would arise if the dielectric surrounding the earth were treated as varying continuously in conductivity, the consequences of the ionisation theory are investigated by first assuming that the effect produced by the absorption regions which tend to reflect the waves may be represented by taking the earth to be surrounded by a perfect reflector, so that the tangential component of the electric force is zero. The theory is then modified by attributing a finite conductivity to the reflector. G. W. DE T.

**1322.** *Electromagnetic Waves.* **T. J. I'A. Bromwich.** (Phil. Mag. 38. pp. 143–164, July, 1919.)—The author first expresses the fundamental electromagnetic equations in terms of general orthogonal curvilinear coordinates. He then shows that, at any rate for spherical polar coordinates, and in the case of problems in which the whole of the angular space is used, the most general possible solution of the equations can be obtained by the superposition of two special solutions. It is then shown by a detailed examination that all the known types of solution are included in the solution so obtained. The solution is shown to be equivalent to the Cartesian solution given by A. E. H. Love in 1901, and the determination in polar coordinates of the field of an oscillating electron and of the rate of radiation of energy shows the analysis to be much simpler and easier to grasp than when the usual Cartesian forms are employed. The author's solution is also shown to include certain general solutions, by Hertz and Fitzgerald, of problems in which there is an axis of symmetry, and to lead, moreover, to Rayleigh's solution for waves travelling along two long parallel conducting wires. G. W. DE T.

**1323.** *Diffraction of Electromagnetic Waves.* **M. Sjöström.** (Jahrb. d. Drahtl. Tele. 14. pp. 171–180, July, 1919.)—An experimental investigation is described of the diffraction of electromagnetic waves at the straight edge of a metal screen. A small linear oscillator of the Hertz type was employed, giving waves of 40 cm. wave-length. The experiments were carried out in a large room, so that reflection from the walls was negligible. A large sheet of zinc was used for the screen. Diagrams are given showing the radiation intensity in the neighbourhood of the screen. The general characteristics are in agreement with the theoretical treatment of the two-dimensional problem given by Oseen, and the results show that Maxwell's equations are quite valid for oscillations of the frequency ($10^9$) corresponding to Hertzian waves. A. W.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**1324.** *Electronic Constants of Bismuth.* **G. C. Trabacchi.** (N. Cimento, 16. pp. 197–212, Nov.–Dec., 1918.)—Proceeding along the lines of Drude's theory of metallic conduction and the relations deduced by Corbino, the author determines the ionic density and mobility by finding the variation of resistance of a plate of bismuth in magnetic fields and the simultaneous variation of the Hall-effect. He uses a circular plate of pure Bi 0·8 mm. thick and 4·5 cm. in diam. placed within a thin water-jacket between the poles of a Weiss electromagnet. The specific conductivity is found to be 0·79 × $10^4$ in zero field. Following up the curves of variation of both conductivity and Hall-effect to very small fields, the following results are obtained: Number of positive ions per cm.$^3$, 0·5 × $10^{18}$; mobility, 5·4 × $10^{15}$. Number of negative ions per cm.$^3$, 1·8 × $10^{18}$; mobility, 15·6 × $10^{15}$. Repeating the experiment at −65° C. the corresponding numbers are 0·24 × $10^{18}$; 18·9 × $10^{15}$; 0·98 × $10^{18}$; 41·6 × $10^{15}$. This agrees admirably with data derived from the law of Wiedemann and Franz. At ordinary temperatures the positive ions account for only about 8 % of the conductivity.

E. E. F.

**1325.** *Rectifying Action in Selenium.* **H. Greinacher** and **C. W. Miller.** (Deutsch. Phys. Gesell., Verh. 18. pp. 283–296, May 30, 1916.)—The authors distinguish two rectifying effects: a normal effect due to some asymmetry in the selenium cell employed; and an anomalous effect due to the inequality of the two halves of the alternate-current curve. The latter is possibly due to the failure of Ohm's law in the case of selenium [see Abs. 1260 (1912)]. In addition to the Shelford Bidwell cells formerly used, a cell formed like a condenser, with a layer of Se between two small Al plates, was studied. [See also Abs. 539 (1917) and 988 (1919.)] E. E. F.

**1326.** *New Method for Measurement of Specific Inductive Capacity of Liquids.* **F. Michaud** and **A. Balloul.** (Ann. de Physique, 12. pp. 295–322, May–June, 1919.)—The apparatus described is based on the same principle as that of Quincke, but easier to use. It consists of a cylindrical condenser with axis vertical, the space between the cylinders being connected at the lower end with a narrow U-tube of glass. Part of this space is occupied by the liquid, the level of which can be observed by the U-tube. Under the action of an electric field between the cylinders the level of the liquid in the condenser rises, the change being measured by the consequent fall of the surface in the U-tube. The theory of the method is worked out and possible errors are discussed. A formula of sufficient accuracy is given as $K-1=8\pi e^2ghd/E^2$, where $k$ is the dielectric constant of the liquid of density $d$, $g$ the gravitational constant, $e$ the difference in the radii of the cylinders, $h$ the change in the level of the liquid between the cylinders when a potential difference E is applied.

Results for benzene, vaseline oil, and other organic liquids are given. In the case of a solution of phenol in benzene, a simple law of mixtures is in error, the dielectric constant passing through a maximum for a concentration of about 11 %.

The effect of "electro-osmosis" is discussed. When the electric field between the plates is not uniform, its variation will be accompanied by corresponding variations in concentration of the solution. This alters by diffusion, tending to make the dielectric constant increase until equilibrium is established between the electric forces disturbing the uniformity of the mixture and the osmotic forces tending to re-establish it. The effect, the further study of which is proposed, is neglected here owing to the slowness of diffusion in the liquids.

The apparatus may also be utilised as an electrometer. T. H

**1327.** *Temperature Coefficient of Resistance of Pure Metals.* **L. Holborn.** (Ann. d. Physik, 59. 2. pp. 145–169, June 20, 1919. From the Physikal.-Techn. Reichsanstalt.)—The temperature coefficient of resistance of a metal is greater the higher the degree of purity. The author gives a table of the mean temperature coefficients between 0° and 100° C. for various pure metals compiled from the data of numerous investigators. The range of temperature over which the observations extend is not always wide, and for this reason the author has conducted a series of resistance determinations on a number of metals at temperatures −192°, −78°, 0°, 100°, 200°, 300°, 400°, and 500° C. The specimens were in the form of drawn wire and were annealed for a sufficient time to have a definite zero resistance. The results are given in tables in the paper. The following shows how the mean temperature coefficient varies with the temperature:—

MEAN TEMPERATURE COEFFICIENT OF RESISTANCE $\times 10^2$.

| Metal. | Annealing Temperature. | −135°. | −39°. | +50°. | 150°. | 250°. | 350°. | 450°. |
|---|---|---|---|---|---|---|---|---|
| Fe I. | 500° | 0·4247 | 0·5322 | 0·6572 | 0·8330 | 1·0228 | 1·1817 | 1·4065 |
| Fe II. | 380 | 0·4311 | 0·5392 | 0·6476 | — | — | — | — |
| Ni | 500 | 0·3257 | 0·4230 | 0·5210 | 0·6552 | 0·8626 | 1·0597 | 0·4410 |
| W I. | (2500) | 0·4350 | 0·4453 | 0·4645 | 0·4926 | 0·5355 | 0·5468 | — |
| Al III. | 250 | 0·4404 | 0·4533 | 0·4469 | 0·4450 | — | — | — |
| Bi | 200 | 0·3126 | 0·3685 | 0·4456 | 0·6266 | — | — | — |
| Al IV. | 250 | 0·4397 | 0·4495 | 0·4449 | — | — | — | — |
| Rh | 600 | 0·4367 | 0·4362 | 0·4428 | 0·4599 | 0·4800 | 0·5078 | 0·5278 |
| Al IV. | 300 | 0·4354 | 0·4473 | 0·4423 | 0·4476 | 0·4562 | — | — |
| Mo II. | 500 | 0·4154 | 0·4271 | 0·4350 | 0·4495 | 0·4641 | 0·4778 | — |
| Cu | 380 | 0·4496 | 0·4355 | 0·4331 | 0·4328 | 0·4423 | — | — |
| Cu | 500 | 0·4473 | 0·4357 | 0·4313 | 0·4344 | 0·4421 | 0·4526 | 0·4657 |
| Al V. | 250 | 0·4302 | 0·4314 | 0·4255 | 0·4285 | — | — | — |
| Al V. | 250 | 0·4289 | 0·4315 | 0·4255 | — | — | — | — |
| Cd | 220 | 0·3856 | 0·3937 | 0·4236 | 0·4622 | — | — | — |
| Pb | 200 | 0·3749 | 0·3963 | 0·4222 | 0·4545 | 0·5022 | — | — |
| Zn | 200 | 0·4091 | 0·4021 | 0·4126 | 0·4409 | 0·4849 | — | — |
| Al V. | 500 | 0·4135 | 0·4171 | 0·4120 | 0·4165 | — | — | — |
| Mo I. | 500 | 0·3937 | 0·4031 | 0·4100 | 0·4233 | 0·4371 | 0·4464 | 0·4530 |
| Ag | 500 | 0·4185 | 0·4050 | 0·4098 | 0·4196 | 0·4344 | 0·4487 | — |
| Al IV. | 600 | 0·4052 | 0·4135 | 0·4096 | 0·4252 | 0·4252 | 0·4495 | 0·5245 |
| W II. | 300 | 0·3922 | 0·3931 | 0·4048 | 0·4280 | 0·4397 | — | — |
| Au | 500 | 0·4020 | 0·3903 | 0·3982 | 0·4104 | 0·4283 | 0·4452 | 0·4651 |
| Ir | 600 | 0·4110 | 0·3926 | 0·3924 | 0·4012 | 0·4034 | 0·4359 | 0·4393 |
| Pt | 800 | 0·4211 | 0·4026 | 0·3920 | 0·3804 | 0·3688 | 0·3572 | 0·3456 |
| Pd I. | 500 | 0·4339 | 0·4031 | 0·3770 | 0·3511 | 0·3302 | 0·3092 | — |
| Pd II. | 500 | 0·4322 | 0·3979 | 0·3726 | 0·3495 | 0·3273 | 0·3067 | 0·2851 |
| Ta | (2200) | 0·3796 | 0·3455 | 0·3468 | 0·3149 | — | — | — |

In the first column the metals are arranged so that the ratio $R/R_0$ gradually diminishes and the metals Pt, Pd, and Ta, which have the least value for this ratio, are peculiar in that the coefficient decreases with increase of temperature. The values of the ratio $R/R_{-192}$ are plotted as ordinates against the temperature for some of the metals. The curves are slightly convex to the axis of temperature—the convexity being most marked in the case of Zn, Cd, Pb, and Bi. In the case of Al the greatest temperature coefficient occurs with the specimen of least degree of purity; but further experiments are in progress on this point. For low temperatures W and Mo have proved suitable materials for resistance thermometers. L. L.

**1328.** *Maintenance of Mechanical Oscillations by Means of Three-Electrode Valves.* **H. Abraham** and **E. Bloch.** (Comptes Rendus, 168. pp. 1197–1198, June 16, 1919.)—The fact that a 3-electrode valve behaves as if it were the seat of a negative resistance may be utilised to maintain mechanical oscillations of any frequency. Thus, if a pendulum be furnished with a horseshoe magnet, whose two branches engage with two bobbins of copper wire having a large number of turns, and if one of these is connected in the grid circuit, the other in the anode circuit of a valve, the oscillations will be sustained if the direction of the windings is suitable. If the direction of one winding is reversed, the oscillations will be damped more rapidly than without the valve in operation. If several valves are arranged in parallel, or if a multi-stage amplifier be employed, the effects can be increased, so that the ordinary equilibrium position may be unstable, the pendulum then starting from rest when the valve circuit is brought into operation. The operation of the arrangement is very simple. The movement of the pendulum produces, by induction, in the first coil, an e.m.f. proportional to the velocity. This e.m.f. acting on the grid of the first valve generates in the anode circuit of the last valve variations of current which, to a first approximation, are also proportional to the velocity of the pendulum, and if the direction is suitable these currents give rise to mechanical forces on the movable magnet which serve to sustain the motion. A similar arrangement can be utilised for maintaining the oscillations of a tuning-fork of frequency too high for successful operation with an ordinary make and break. A fork of 1000 frequency can easily be maintained in this way. Two telephone electromagnets with high-resistance windings are arranged on either side of the two prongs of the fork. The ends of one coil are connected to the input terminals of a three-valve note magnifier, the ends of the other coil being connected to the output terminals. The fork then commences to vibrate, and the vibrations are maintained. If the connections to one coil are reversed the vibrations of the fork are, on the contrary, more rapidly damped out than if the valve circuit is not in operation. A. W.

**1329.** *Measurement of Frequency of Alternating Current.* **A. Žáček.** (Phys. Zeits. 20. pp. 348–350, Aug. 1, 1919.)—The method here described is suitable for frequencies ranging from 800 to 6000 cycles per sec. The principle of the method is as follows: The alternating current whose frequency is to be determined is passed through a circuit consisting of two arms in parallel, one containing only an inductionless resistance and the other having either self-induction or capacity. These arms are adjusted until the current through both is the same, when the frequency can be calculated from the known values of the resistance and self-induction (or capacity) in the two arms. In the actual apparatus a choking coil is introduced in the main circuit to suppress as far as possible the higher harmonics, and each branch contains the hot wire of a thermo-element. The other diagonals of these thermo-elements are connected in opposition to the coils of a differential galvanometer. If the sensitiveness of both thermo-elements is the same the arrangment gives a null method. If, however, the sensitiveness of one element differs appreciably from that of the other, a six-pole switch is used (1) to put the two branches in parallel as above, and (2) to cut out the inductionless resistance and send the current through the self-inductance and the two thermo-elements in series. The calculations of the frequency can then be effected. A. W.

## ALTERNATING CURRENTS AND MAGNETISM.

**1330.** *Magnetic Properties of Iron-Vanadium Alloys, and a Sensitive Astatic Magnetometer.* **D. Dieterle.** (Ann. d. Physik, 59. 4. pp. 343–392, July 25, 1919.)—The first part of this paper gives a description of a portable sensitive astatic magnetometer similar in principle to that designed by Kohlrausch and Holborn [Abs. 1814 (1904)]. The size of the magnets is reduced considerably [0·88 cm. long, 0·0036 sq. cm. cross-section]. They are mounted parallel to one another at a distance apart of 105 cm.; the system is suspended by a quartz fibre 17 cm. long. The damping is adjustable. The author has used the instrument to study the influence of the number and magnitude of the steps in the step-by-step process of magnetisation. For weak fields, the larger the number of steps to the assigned value, the greater is the induction attained. With higher magnetising fields this is not noticeable. The coercive force is always larger the greater the number of steps, and the percentage increase is greater the smaller the value of the max. field. Magnetisation and hysteresis curves were obtained for three vanadium-iron alloys. The percentage compositions of these alloys are—

| | V. | C. | Mn. | Si. |
|---|---|---|---|---|
| I. | 0·64 | 0·22 | 0·28 | 0·07 |
| II. | 1·75 | 0·28 | 0·29 | 0·08 |
| III. | 3·60 | 0·36 | 0·20 | 0·20 |

The specimens were kept for two hours at 850° C. and then allowed to cool slowly. Ellipsoids were turned [length of axes 22 × 0·4 cm.] and magnetically investigated [condition A]. They were then annealed (B), reinvestigated, and finally hardened (C). Complete tables of results, curves and microphotographs are given in the paper. A brief summary is appended.

MAGNETISATION CURVE.

| Material. | Condition. | $H_{max.}$ | $B_{max.}$ | $\mu_{max.}$ | At B. | And H. |
|---|---|---|---|---|---|---|
| I. | A | 81·0 | 15,960 | 1010 | 8400 | 8·4 |
| | B | 79·6 | 16,780 | 1210 | 8500 | 7·1 |
| | C | 81·2 | 15,460 | 810 | 9600 | 30·8 |
| II. | A | 78·8 | 16,890 | 955 | 10,200 | 10·8 |
| | B | 79·4 | 16,850 | 1280 | 10,800 | 8·4 |
| | C | 80·1 | 16,600 | 680 | 7500 | 12·0 |
| III. | A | 80·5 | 16,220 | 880 | 8500 | 10·2 |
| | B | 80·7 | 15,800 | 1085 | 9500 | 8·8 |
| | C | 82·0 | 15,690 | 595 | 7500 | 12·5 |

HYSTERESIS CURVES.

| Material. | Condition. | $H_{max.}$ | $B_{max.}$ | $B_{rem.}$ | $H_{coer.}$ | E |
|---|---|---|---|---|---|---|
| I. | A | 80·9 | 14,810 | 11,440 | 4·85 | 12,200 |
| | B | 81·55 | 14,920 | 11,880 | 4·00 | 10,970 |
| | C | 82·7 | 10,480 | 7230 | 14·4 | 20,040 |
| | A | 80·8 | 16,140 | 11,720 | 4·91 | 17,100 |
| | B | 82·8 | 16,750 | 11,600 | 4·01 | 16,000 |
| | C | 80·6 | 15,440 | 10,520 | 21·4 | 41,180 |
| II. | A | 80·8 | 14,970 | 12,920 | 6·09 | 16,050 |
| | B | 80·65 | 15,330 | 14,080 | 5·50 | 14,570 |
| | C | 29·1 | 13,360 | 9860 | 6·05 | 14,220 |
| | A | 83·0 | 16,870 | 13,540 | 6·41 | 22,800 |
| | B | 81·6 | 16,850 | 14,580 | 5·55 | 20,100 |
| | C | 77·7 | 16,570 | 9900 | 6·08 | 19,880 |
| III. | A | 81·6 | 14,180 | 11,580 | 6·04 | 15,070 |
| | B | 81·55 | 14,420 | 13,000 | 5·49 | 13,880 |
| | C | 29·8 | 12,800 | 8650 | 6·10 | 13,190 |
| | A | 80·2 | 16,150 | 12,460 | 6·18 | 22,100 |
| | B | 80·4 | 15,920 | 13,610 | 5·60 | 19,800 |
| | C | 79·8 | 15,700 | 9620 | 6·12 | 18,180 |

The author concludes that alloying with vanadium is advantageous owing to ease of combination with C and O. By annealing the alloys become magnetically "softer." A hardening of the alloys with higher V-content is not credible. It is not suitable for permanent magnets. The author's results do not agree with those of Lonsdale who investigated a vanadium-steel ring of composition very similar to III [Abs. 1780 (1918)]. L. L.

1331. *Magnetostriction in Iron.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 267–272, July, 1919.)—Observations of an iron rod, using an interferometer, indicated no definite limit to the contraction of the rod in fields up to 800 c.g.s. This anomalous behaviour was found to be caused by rise of temperature in the magnetising coil. An explanation to account for the course of the magnetostriction is based on the rotation of the molecular magnets. G. E. A.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1332. *Relationship of the Rare Earths to the Periodic System.* **R. Vogel.** (Zeits. Anorg. Chem. 102. pp. 177–200, April 9, 1918.)—The rare elements do not really fit chemically and crystographically into the 3rd and 4th group, nor into other groups. According to Tammann elements of the same group should have little affinity for one another and not form stable compounds with one another; from this point of view cerium cannot be classed with any group, and it is especially remarkable that cerium forms with bismuth (melting-point very low, 260°) a compound $Ce_4Bi_3$ which has the highest melting-point of any Ce compound known, 1630°. When the elements are grouped as to atomic numbers there should be 16 elements between Ba (56) and Ta (73); 14 of these are known rare-earth elements, two are missing, and the rare elements must form a group of their own. The author shows how they may be arranged on an ascending spiral in a loop from the main spiral. Similar loops are ascribed to the triads, the iron groups (Fe, Co, Ni); Ru, Rh, Pd; and Os, Ir, Pt; all the strongly magnetic or paramagnetic elements are somewhat anomalous in the periodic system. The rare earths show periodicity in magnetic and other properties, and certainly fit less well into the periodic system than even the 8th group. H. B.

1333. *New Method of Chemical Analysis.* **A. W. Hull.** (Am. Chem. Soc., J. 41. pp. 1168–1175, Aug., 1919.)—A method of analysis is described, based on Debye and Scherrer's X-ray spectroscopy of so-called amorphous substances. In this method X-rays, after passing through suitable absorbing screens to render the beam homogenous, and through two suitable slits, are allowed to fall on a small cylindrical tube containing the powdered substance to be analysed. The "reflected" X-rays are received on a cylindrical photographic film. By comparing with similar photographs of known elements and compounds the photographic record obtained in this way, it is possible to distinguish the constituent compounds in the unknown powder. Typical analyses, made in the manner described, are given in illustration.

A. B. W.

1334. *Relation among Atomic Weights of Chemical Elements.* **S. Ono.** (Phys. Math. Soc. Japan, Proc. 1. pp. 231–236, July, 1919.)—It is well known that the atomic weight of the chemical element is roughly twice the atomic number when it is comparatively small, but for elements of higher atomic numbers the relation between the atomic weight and the atomic number has been considered to be complicated. Harkins and Wilson (Am. Chem. Soc., J. 37. p. 6. (1913) and Harkins and Hall [Abs. 471 (1916)] (showed that the atomic weight W is given by the equations $W = 2N + \{\frac{1}{2} + \frac{1}{2}(-1)^{N-1}\}$ for lighter elements, and for heavier elements by $W = 2(N + n) + \{\frac{1}{2} + \frac{1}{2}(-1)_{N-1}\}$ where N is the atomic number, and *n* has varying values according to groups of the elements, this number being zero for the lighter elements.

In the present paper the author attempts to show that the atomic weights of all chemical elements can be represented approximately by a simple function of integer, which is a little greater than the atomic number. He concludes that the atomic weight A may be given by the formula $A = N^{\eta}$, where $\eta = 1{\cdot}204$ and N is equal to Moseley's atomic number + 2, or Rydberg's ordinals. A. B. W.

1335. *Relative Adsorption of Mixtures of Oxygen and Nitrogen in Coconut-Shell Charcoal.* **H. B. Lemon** and **K. Blodgett.** (Nat. Acad. Sci., Proc. 5. pp. 289–291, July, 1919.)—The coconut charcoal, which weighed 6·5 gm. when saturated with dry air at 20 and 750 mm. pressure, was contained in Pyrex glass bulbs which could be outgassed by a diffusion pump. Outgassing was maintained for 4½ hours at 582°. After outgassing, the bulbs were immersed in liquid air of definite age and temperature, and whilst immersed were exposed to the given gas mixture contained in a constant volume of 975 $\text{cm}^3$. The fall in pressure was observed during the process of adsorption. The results obtained for various mixtures of oxygen and nitrogen are given in graphs, log $p$ in cm. being plotted against log $t$ in minutes after the adsorption began. A discussion of these graphs is not given, except that it is noted that the logarithm of the pressure reached by saturation is almost in a linear relation with the percentage of oxygen in the mixture. In no case does the final pressure of a mixture fall as low as the sum of the final pressures of the two components when adsorbed separately. In other words, each component in the mixture hinders the adsorption of the other. In the case of a pure gas, adsorption is much more complete when the gas is admitted in portions at a time than when it is adsorbed all at once. In adsorbing equal parts of oxygen and nitrogen it seems to be immaterial which gas is admitted first, the final pressure being the same within the limits of experimental error. If a mixture of the two gases is adsorbed the final pressure reached is considerably higher than when the gases are adsorbed separately. T. S. P.

1336. *Variations, due to Heat Treatment, in the Rate of Adsorption of Air by Coconut-Shell Charcoal.* **H. B. Lemon.** (Nat. Acad. Sci., Proc. 5. pp. 291–295, July, 1919.)—It is known that the adsorption power of charcoal made from the same material varies with different specimens, and also that it is very different when the same sample is used repeatedly. The author now shows that the heat-treatment of the specimen during carbonisation and also during successive "outgassings" is a decisive factor in the control of the efficiency of the material as an adsorbent. As in the previous paper [preceding Abs.] the rate of adsorption of a gas was measured by observing the rate of decrease in pressure, and the results obtained are plotted in a similar manner. Three samples of coconut shell were carbonised at 900°, 850° and 800° respectively. They were all outgassed simultaneously for 6 hours at 425°, and tested in rapid succession on the same apparatus. The influence of the temperature of carbonisation is shown by the fact that the initial pressure of 90 cm. was reduced in 10 mins. to 20 cm., 0·71 cm., and 0·0008 cm. respectively for the three samples. If the same sample is carbonised at 850° and then outgassed repeatedly at 600°, the adsorptive power being determined after each outgassing, the rate and amount of adsorption increases continuously up to a maximum. If the carbonisation takes place at 670° and the outgassings at higher temperatures, 800° to 905°, the adsorptive power gradually decreases. Activity can then be gradually restored by repeated outgassings at lower temperatures. Permanent loss of activity can always be produced on any sample by heating to 1200°. Two hypotheses which have been advanced to account for these phenomena are discussed, but the author comes to no definite conclusion on the matter. T. S. P.

1337. *Research Work on Malleable Iron.* **E. Touceda.** (Am. Soc. Mech. Eng., J. 41. pp. 598–600, July, 1919.)—This consists of an abstract of an account of four years' research work undertaken for the American Malleable Castings Association, and shows how the quality of the product of its members has steadily improved since the beginning of the research work.

Malleable iron castings, due to lack of uniformity and dependability, were rapidly being displaced by other materials before this work was undertaken. Records of tests carried out in 1911 showed an average ultimate strength of 39,882 lbs. per sq. in., with an elongation of under 5 %. Tests carried out in March, 1919, showed that 44 % of the test-bars submitted during that month had an ultimate strength of 52,000 lbs. with an elongation of 14·67 %. These tests show that, contrary to generally accepted theories, the elongation increases with the ultimate strength. A description is given of the process of manufacture, of the annealing ovens, and the annealing process. The effects of time in cooling through the critical range and of successive anneals are described and illustrated by means of photomicrographs. The appearance of fractures of test-pieces receives attention, and it is shown that the appearance of the fracture is often of more value than the microstructure. Picture-frame fractures which show a decarburised surface border, an inner ring of coarsely laminated pearlite and within this a core of normal malleable iron are fully described, and it is shown that these result when the surface decarburisation takes place in such a manner as to form an inner layer containing about 0·9 % carbon. When this layer is once formed the carbon, which passes to the outer, decarburised border, is replenished by carbon from the core. The effect of heating malleable castings is shown, and it is pointed out that for straightening, brazing, etc., the temperature used should be well under 1400°F. C. O. B.

1338. *Macrography of Steel. Etching Tests.* **H. le Chatelier** and **B. Bogitch.** (Rev. de Mét. 16. pp. 129–139, March-April, 1919.)—The macroscopic structure of steel is on a scale about 100 times as large as that of the microscopic structure. Microscopic heterogeneity is due entirely to the distribution of the carbon ; the structure is fugitive, being modified by heating and completely changed by quenching from high temperatures. The origin of macroscopic heterogeneity is not clearly known, but is generally attributed to the impurities in the steel. It is independent of any normal heat treatment. Although there is no correlation between the two types of structure, works practice is showing the great importance of macrography, since the quality of the steel is directly related to the degree of macroscopic heterogeneity. While Stead attributes the structure developed by his reagent to irregularities in the distribution of phosphorus the authors are of the opinion that it is due to dissolved oxygen. Samples of electrolytic iron, with and without the addition of varying quantities of impurities (Si, S, P, Mn, & O), have been melted in reducing and oxidising atmospheres, cast and subjected to macrographic examination. The observations point to the fact of macroscopic heterogeneity being entirely due to the presence of dissolved oxygen. At the moment of solidification the whole of the oxygen is not given up as CO, but a portion remains in solution as FeO which concentrates in the later portions of solidifying metal. It is possible that part of the oxygen exists as a phosphate or oxy-phosphate of iron. When the oxygen content is below 0·01 % Stead's reagent does not attack the steel, and when the content exceeds 0·1 % the attack becomes progressively worse as the oxygen-content increases. Stead's reagent colours the low-oxygen areas of the metal, while the other macrographic etching reagents (Heyn's reagent, iodine, and moderately strong acids) attack the impure portions of the metal. In macroscopic examination oxygen plays the same rôle as does carbon in microscopic examination. F. C. A. H. L.

**1889.** *Inter-crystalline Fracture of Metals under Prolonged Application of Stress.* **W. Rosenhain** and **S. L. Archbutt.** (Roy. Soc., Proc. **96.** pp. 55–68, Aug. 1, 1919.)—Deals with a group of phenomena some of which have long been known in the case of brass as "season cracking," and describes a series of observations on some cases of inter-crystalline fracture in various metals. A satisfactory explanation of "season cracking" has not previously been put forward, but it has been found that the fracture follows the inter-crystalline boundaries. The present results refer mostly to an Al alloy containing Zn and Cu, but illustrations are also given from lead and mild steel. The Al alloy in an over-annealed condition shows no abnormal properties when tested in an ordinary tensile testing machine, but after bending to a curve of moderate radius for a period varying from a few minutes to several days, the specimen breaks, the fracture being generally accompanied by many ramifying cracks which are strictly inter-crystalline. The possible existence of a thin layer of amorphous metal between adjacent crystals and in a state corresponding to that of a greatly under-cooled liquid is referred to and it is pointed out that if far below its freezing-point, such "liquid" will be in an extremely viscous condition resembling such a substance as glass. Towards loads applied at the rates employed even in a very slow tensile testing-machine, such a substance will behave like a solid of apparently high elastic limit; the crystals, on the other hand, are capable of undergoing deformation by slip under relatively light stresses. Deformation and fracture will therefore occur by rupture of the crystals themselves and this is the type of fracture met with under normal conditions. On the other hand, an amorphous cement of the nature of an under-cooled liquid will become rapidly less viscous with rising temperature, whereas there is no reason to believe that the physical properties of solid crystals undergo any very rapid change with rising temperature, and it has been shown that at some temperature between the ordinary and the freezing-point of the metal the fracture will be purely inter-crystalline. In the case of several pure metals such inter-crystalline fractures have been produced by the application of light stresses at a temperature just below the freezing-points, and it is probable that with higher stresses applied for a longer time, similar inter-crystalline fractures would take place at lower temperatures. The following explanation of the inter-crystalline fracture of certain metals, resulting from prolonged exposure to stress is put forward by the authors: That the constituent crystals of a metal are held together by an amorphous inter-crystalline cement which, in some metals at all events, is sufficiently mobile to yield to the tendency of any applied stress to produce flow. In such cases it would follow that the inter-crystalline rupture must occur, after the lapse of sufficient time, as the result of the prolonged action even of small stresses which may arise either from externally applied forces or from elastic deformations and consequent internal stresses.

Cases of "season cracking" are comparatively rare, and it is necessary to take into consideration the conditions existing at the crystal boundaries, as it is obvious that flow sufficient to cause rupture cannot occur unless the shape of the boundaries is favourable to movement. In cases where the crystals are thoroughly dovetailed into one another, rupture along the boundaries cannot occur; although such a truly "interlocked" structure is not met with in metals, there are wide differences in the character of the crystal boundaries and especially between the crystals of the same metal in different conditions of thermal and mechanical treatment. Crystal growth in many cases takes place by a process in which the growing crystal thrusts out projections into its neighbours, and it follows that the surface of a growing crystal is likely to be covered with minute irregularities, and as growth ceases the outlines of the crystals may be expected to become smoother. It follows that inter-crystalline fracture under prolonged application of stress should only occur where the crystal boundaries have assumed smooth and regular outlines.

In the case of the Al alloy, inter-crystalline fracture is found to occur after drastic annealing, for example by heating to 450°, by which operation the crystals attain a considerable size and exhibit smooth and regular boundaries. In the case of a sample of lead examined, inter-crystalline fracture was found in patches where the crystals had assumed a smooth and regular formation. Elsewhere in the same specimen the crystals showed ragged, almost feathery edges typical of lead crystals in process of active growth. In the case of mild steel, inter-crystalline failures are rare and are associated with heat-treatment consisting of prolonged annealing or very slow cooling through the range just below the lowest critical point of the steel, which causes smooth and regular crystal outlines. C. O. B.

1340. *Copper Alloys of High Tenacity.* **O. F. Hudson.** (Birmingham Metallurgical Soc. 7. pp. 179–190; Disc., 191–197, May, 1919.)—Summarises the properties of the pure or simple brasses and shows how these properties may be controlled by work and heat-treatment. Gives the effects of additions of other metals including Sn, Pb, Fe, Mn, Ni, and Al, forming special or complex brasses. Constitutionally, these special or high tensile brasses consist of alloys showing a mixture of $\alpha$ and $\beta$ or of the $\beta$ constituent alone, and generally the added metals are retained in solid solution. The method of increasing the tensile strength of a simple brass by cold work is viewed with suspicion, and there is a tendency to carry the method of addition of special metals for this purpose too far. The author suggests that the best results would be obtained by the addition of certain metals, followed by mechanical work and heat-treatment. C. O. B.

1341. *Determining Gases in Steel and the Deoxidation of Steel.* **J. R. Cain.** (Am. Inst. Mining Eng., Bull. No. 152. pp. 1309–1322, Aug., 1919.)—Summarises the *rôle* of gases in ferrous metallurgical processes and the effect of gases on the physical properties of iron and steel. Reviews previous researches on methods of determining gases in steel and gives a summary of results obtained by previous workers. A list is given of results which an adequate investigation of the subject should aim at obtaining; this deals specially with the faults of existing analytical methods. C. O. B.